Modeling & Forecasting US Electricity Consumption

Mark D. Hutson, Frederick L. Joutz

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1 Overview

Forecasting electricity consumption has often prefered to treat socioeconomic activity and wealth as exogenous. The motivation for this research is to endogenize electricity consumption with economic activity by introducing electricity demand, and the interactions between electricity use and economic activity, into macroeconomic demand equations. In this paper, I create an energy and macroeconomic model that examines the dynamics of the US electricity markets at the sectoral level on a monthly basis. I use nearly a quarter century of monthly data to model the dynamics of several macroeconomic and electricity series, then combine these equations into a single large model. By incorporating multiple sectors of demand at once and using high-frequency data, the model provides robust feedbacks between electricity markets as well as the larger macroeconomy. The short-run is modeled simultaneously with the long-run and seasonal properties of the data using a equilibrium-disturbance technique. The equilibrium relationships are specified first at the individual equation level; these equations are then linked together to create a single large, cross-sector model. This approach allows for proper identification and specification of feedback between the electricity sectors and the economy. Using this model, I conduct several forecasting exercises to examine the impact of the 2007-2008 recession. I also conduct two sets of simulations: one scenario examines the effects of instituting a carbon price and the second examines several weather-based scenarios.

2 Methodology

The combined electricity-macro model incorporates several different modeling approaches. Specifically, the model is built using a structural-equation approach while incorporating strengths of dynamics-based system of equations; this combined approach sidesteps the problematic dimensionality of using a large dynamic system while also limiting the potential for omitted variable bias associated with structural models at the equation level. The dynamics-based approach is used to identify short-run, long-run, and seasonal relationships in each equation, with the strongest and most predictive relationships introduced into the large system of equations.

Much like a traditional structural model, the model is initially specified at the individual equation level before being combined into the large model. However, each initial equation specification is used to identify relationships that exist within the data; these relationships are then introduced into other single-equations to determine if they provide predictive power. This identification process relies on techniques used in dynamics-based model specification, specifically the General-to-Specific approach advocated by Hendry based on the Theory of Reduction advanced by Haavelmo. Thus, the final specification of each individual equation is determined using an iterative process that identifies the strongest short-run, long-run, and seasonal relationships within the data. The steps for each equation are as follows:

1. Specification of initial GUM
2. Specification and reduction of 8 sub-models for relationship identification
3. Re-specification of initial GUM with relevant long-run, seasonal, and cross-equation relationships
4. Reduction of updated equations & model selection
5. Relevant data transformation

Each equation is estimated using data spanning 1986.1 through 2010.12. These final individually-specified equations are then introduced into the large system. This equation-by-equation approach allows for the proper identification of the salient relationships in the dynamics of each series, and the iterative process allows for a structured model to include robust feedbacks that are identified at various time durations.

The model then forecasts a series of counter-factual scenarios. The first set involves forecasting the model at various dates associated with the 2007-2008 recession. The second series involves various levels of a carbon tax levied on coal, natural gas, & petroleum products used as inputs in the electricity sectors. The third series involves running several weather scenarios, with the number of heating and cooling degree-days being 10%, 20%, and 30% above or below their historical norms.

3 Results & Conclusion

The paper constructs a large multivariate model that captures the feedbacks between several energy markets and the broader economy. This model is built using a combined structural- and dynamics-based approach, gearing the model's performance towards forecasting performance while also identifying critical short-run, long-run, and seasonal dynamics in the process. This system includes 26 equations. The model is tested by generating several forecasts around the 2007-2008 recession and recovery; these simulations are evaluated against real data. The model also simulates several weather and carbon price scenarios.

4 Selected References

An extensive bibliography is available from the author, as there are 61 references.

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